



US006483461B1

(12) **United States Patent**  
Matheney et al.

(10) Patent No.: **US 6,483,461 B1**  
(45) Date of Patent: **Nov. 19, 2002**

(54) **APPARATUS AND METHOD FOR  
LOCATING OBJECTS IN A  
THREE-DIMENSIONAL SPACE**

(75) Inventors: **Jack Thomas Matheney**, Madison;  
**Linda M. Lee**, Harvest, both of AL  
(US); **Donald David Mondul**, Dallas,  
TX (US)

(73) Assignee: **Time Domain Corporation**, Huntsville,  
AL (US)

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/645,921**

(22) Filed: **Aug. 24, 2000**

(51) Int. Cl.<sup>7</sup> ..... **G01S 3/02**

(52) U.S. Cl. .... **342/463; 342/457**

(58) Field of Search ..... **342/463, 457**

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,068,473 A	12/1962	Muth et al.
3,213,449 A	10/1965	Kobayashi
3,376,504 A	4/1968	Chick
3,396,393 A	8/1968	Wagner

(List continued on next page.)

Primary Examiner—Theodore M. Blum

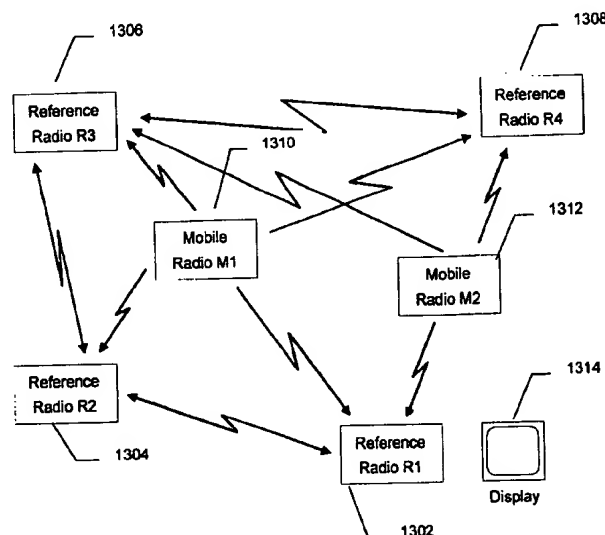
(74) Attorney, Agent, or Firm—Law Office of Donald D.  
Mondul

(57) **ABSTRACT**

A system for locating of objects in a three-dimensional space comprises: (a) an impulse radio network including at least three reference impulse radio units and at least one mobile position indicating apparatus; position information relating the impulse radio units is recorded by at least one indicating impulse radio unit; the impulse radio units are in communication; and (b) an affixing structure for affixing a respective mobile position indicating apparatus with a respective object. A respective mobile position indicating apparatus transmits an impulse radio identifying signal that is received by a receiving impulse radio unit. An indicating impulse radio unit cooperates with the receiving impulse radio unit in using the identifying signal for developing coordinate information for locating the respective mobile position indicating apparatus. The method comprises the steps of: (a) providing an impulse radio network including at least three reference impulse radio units and at least one mobile position indicating apparatus; position information relating the impulse radio units is recorded by at least one indicating impulse radio unit; the impulse radio units are in communication; (b) providing an affixing structure for affixing a respective mobile position indicating apparatus with a respective object; (c) transmitting an impulse radio identifying signal from a respective mobile position indicating apparatus; (d) Receiving the identifying signal by a receiving impulse radio unit; and (e) operating an indicating impulse radio unit in cooperation with the receiving impulse radio unit to determine the location of the mobile position indicating apparatus.

**20 Claims, 24 Drawing Sheets**

1300



## U.S. PATENT DOCUMENTS

3,461,452 A 8/1969 Welter  
 4,161,730 A 7/1979 Anderson et al.  
 4,315,260 A 2/1982 Kupfer  
 4,543,580 A 9/1985 Bent et al.  
 4,641,317 A 2/1987 Fullerton ..... 375/1  
 4,743,906 A 5/1988 Fullerton ..... 342/27  
 4,813,057 A 3/1989 Fullerton ..... 375/37  
 4,916,429 A 4/1990 Hicks et al.  
 4,916,455 A 4/1990 Bent et al.  
 4,979,186 A 12/1990 Fullerton ..... 375/23  
 5,216,429 A 6/1993 Nakagawa  
 5,278,568 A \* 1/1994 Enge et al. .... 342/367  
 5,363,108 A 11/1994 Fullerton ..... 342/27  
 5,497,160 A 3/1996 Koehler et al.  
 5,499,029 A 3/1996 Bashforth et al.  
 5,510,800 A 4/1996 McEwan

5,552,772 A \* 9/1996 Janky et al.  
 5,589,838 A 12/1996 McEwan  
 5,661,490 A 8/1997 McEwan  
 5,661,492 A \* 8/1997 Shoap et al.  
 5,677,927 A 10/1997 Fullerton et al. .... 375/200  
 5,687,169 A 11/1997 Fullerton ..... 370/324  
 5,748,891 A 5/1998 Fleming et al.  
 5,796,366 A 8/1998 Grebnev et al.  
 5,809,424 A 9/1998 Eizenhoefer  
 5,832,035 A 11/1998 Fullerton ..... 375/210  
 5,859,612 A 1/1999 Gilhousen  
 5,912,644 A \* 6/1999 Wang  
 5,933,079 A 8/1999 Frink  
 6,002,708 A 12/1999 Fleming et al.  
 6,054,950 A 4/2000 Fontana

\* cited by examiner

Also, the present invention enables prison personnel to communicate with or eavesdrop on a prisoner.

It is to be understood that, while the detailed drawings and specific examples given describe preferred embodiments of the invention, they are for the purpose of illustration only, that the apparatus and method of the invention are not limited to the precise details and conditions disclosed and that various changes may be made therein without departing from the spirit of the invention which is defined by the following claims.

We claim:

1. A system for locating a plurality of objects in a three-dimensional space; the system comprising:

(a) a digital time-shift modulated ultra wideband impulse radio network; said impulse radio network employing pulse position modulation for indicating information; said impulse radio network including at least three reference impulse radio units and at least one mobile position indicating apparatus; position information relating said at least three reference impulse radio units being recorded by at least one indicating reference impulse radio unit of said at least three reference impulse radio units; said at least three reference impulse radio units being in mutual communication; and

(b) an affixing structure; said affixing structure affixing a respective mobile position indicating apparatus of said at least one mobile position indicating apparatus with a respective object of said plurality of objects;

a respective mobile position indicating apparatus of said at least one mobile position indicating apparatus transmitting an impulse radio identifying signal; said identifying signal being received by at least one receiving reference impulse radio unit of said plurality of reference impulse radio units; at least one indicating reference impulse radio unit of said at least three reference impulse radio units cooperating with said at least one receiving reference impulse radio unit in using said identifying signal for developing coordinate information for determining said locating of said respective mobile position indicating apparatus.

2. A system for locating a plurality of objects in a three-dimensional space as recited in claim 1 wherein at least one reference impulse radio unit of said at least three reference impulse radio units is a mobile radio unit.

3. A system for locating a plurality of objects in a three-dimensional space as recited in claim 1 wherein said at least three reference impulse radio units are fixed radio units.

4. A system for locating a plurality of objects in a three-dimensional space as recited in claim 1 wherein said plurality of objects includes a plurality of items of rental equipment and wherein said affixing structure affixes said respective mobile position indicating apparatus to a respective item of said plurality of items of rental equipment.

5. A system for locating a plurality of objects in a three-dimensional space as recited in claim 1 wherein said plurality of objects includes a plurality of skier persons and wherein said affixing structure affixes said respective mobile position indicating apparatus to a respective individual skier person of said plurality of skier persons.

6. A system for locating a plurality of objects in a three-dimensional space as recited in claim 5 where in said affixing structure comprises a band structure for fixably encircling a limb of said respective individual skier person.

7. A system for locating a plurality of objects in a three-dimensional space as recited in claim 5 wherein said respective mobile position indicating apparatus is a receiving mobile position indicating apparatus, said receiving

mobile position indicating apparatus at least periodically receiving a location indication from at least one of said at least three reference impulse radio units; said location indication relating to own location of said receiving mobile position indicating apparatus.

8. A system for locating a plurality of objects in a three-dimensional space as recited in claim 7 wherein said receiving mobile position indicating apparatus includes a display element; said receiving mobile position indicating apparatus displaying said own location using said display element.

9. A system for locating equipment pieces in a geographic area; the system comprising:

(a) a digital time-shift modulated ultra wideband impulse radio network; said impulse radio network employing pulse position modulation for indicating information; (1) a plurality of reference impulse radio units; and (2) a plurality of mobile position indicating apparatuses; and

(b) affixing structures associated with said plurality of mobile position indicating apparatuses for affixing respective individual mobile position indicating apparatuses of said plurality of mobile position indicating apparatuses to selected individual equipment pieces of said equipment pieces;

selected mobile position indicating apparatuses of said plurality of mobile position indicating apparatuses being transmitting mobile position indicating apparatuses; said transmitting mobile position indicating apparatuses transmitting respective impulse radio identifying signals; each said respective identifying signal being related to a respective said transmitting mobile position indicating apparatus; said respective identifying signal being received by at least one receiving reference impulse radio unit of said plurality of reference impulse radio units; at least one indicating reference impulse radio unit of said plurality of reference impulse radio units cooperating with said at least one receiving reference impulse radio unit in using said respective identifying signal for developing position information for determining said locating of said respective transmitting mobile position indicating apparatus.

10. A system for locating equipment pieces in a geographic area as recited in claim 9 wherein at least one reference impulse radio unit of said plurality of reference impulse radio units is a mobile radio unit.

11. A system for locating equipment pieces in a geographic area as recited in claim 9 wherein said plurality of reference impulse radio units are fixed radio units.

12. A system for locating persons in a geographic area; the system comprising:

(a) a digital time-shift modulated ultra wideband impulse radio network; said impulse radio network employing pulse position modulation for indicating information; (1) at least three reference impulse radio units; and (2) a plurality of mobile position indicating apparatuses; and

(b) affixing structures associated with said plurality of mobile position indicating apparatuses for affixing respective individual mobile position indicating apparatuses of said plurality of mobile position indicating apparatuses to selected individuals of said persons; first selected mobile position indicating apparatuses of said plurality of mobile position indicating apparatuses being transmitting mobile position indicating apparatuses; said transmitting mobile position indicating apparatuses transmitting respective impulse radio identifying signals; each said respective identifying signal

29

being related to a respective said transmitting mobile position indicating apparatus; said identifying signal being received by at least one receiving reference impulse radio unit of said at least three reference impulse radio units; at least one indicating reference impulse radio unit of said at least three reference impulse radio units cooperating with said at least one receiving reference impulse radio unit in using said respective identifying signal for developing position information for determining location of said respective transmitting mobile position indicating apparatus.

13. A system for locating persons in a geographic area as recited in claim 12 wherein at least one reference impulse radio unit of said at least three reference impulse radio units is a mobile radio unit.

14. A system for locating persons in a geographic area as recited in claim 12 wherein said at least three reference impulse radio units are fixed radio units.

15. A system for locating persons in a geographic area as recited in one of claims 12-14 wherein said at least one mobile position indicating apparatus is in duplex communication with said at least one reference impulse radio unit and wherein said at least one impulse radio unit communicates a generalized coordinate reference signal to said at least one mobile position indicating apparatus; said at least one mobile position indicating apparatus including a display element for displaying said location of said at least one mobile position indicating apparatus.

16. A system for locating persons in a geographic area as recited in claim 12 wherein second selected mobile position indicating apparatuses of said plurality of mobile position indicating apparatuses are receiving mobile position indicating apparatuses, respective said receiving mobile position indicating apparatuses at least periodically receiving a respective location indication from at least one of said at least three reference impulse radio units; said respective location indication relating to own location of said respective receiving mobile position indicating apparatus.

17. A system for locating persons in a geographic area as recited in claim 12 wherein said respective receiving mobile position indicating apparatuses include a display element; said respective receiving mobile position indicating apparatuses displaying said own location using said display element.

18. A method system for locating a plurality of objects in a three-dimensional space; the method comprising the steps of:

- (a) providing a digital time-shift modulated ultra wide-band impulse radio network; said impulse radio network employing pulse position modulation for indicat-

30

ing information; said impulse radio network including at least three reference impulse radio units and at least one mobile position indicating apparatus; position information relating said at least three reference impulse radio units being recorded by at least one indicating reference impulse radio unit of said at least three reference impulse radio units; said at least three reference impulse radio units being in mutual communication;

- (b) providing an affixing structure; said affixing structure affixing a respective mobile position indicating apparatus of said at least one mobile position indicating apparatus with a respective object of said plurality of objects;

- (c) transmitting an impulse radio identifying signal from a respective mobile position indicating apparatus of said at least one mobile position indicating apparatus;

- (d) receiving said identifying signal by at least one receiving reference impulse radio unit of said plurality of reference impulse radio units; and

- (e) operating at least one indicating reference impulse radio unit of said at least three reference impulse radio units in cooperation with said at least one receiving reference impulse radio unit to use said identifying signal to develop coordinate information for determining said locating of said respective mobile position indicating apparatus.

19. A method for locating a plurality of objects in a three-dimensional space as recited in claim 18 wherein said respective mobile position indicating apparatus is a receiving mobile position indicating apparatus, and wherein the method comprises the further step of:

- (f) at least periodically receiving a location indication by said receiving mobile position indicating apparatus from at least one of said at least three reference impulse radio units; said location indication relating to own location of said receiving mobile position indicating apparatus.

20. A method for locating a plurality of objects in a three-dimensional space as recited in claim 19 wherein said receiving mobile position indicating apparatus includes a display element, and wherein the method comprises the further step of:

- (f) displaying said own location at said receiving mobile position indicating apparatus using said display element.

\* \* \* \* \*